

EARLY DEVELOPMENTAL STAGES OF THE ROCK SHRIMP,
SICYONIA BREVIROSTRIS STIMPSON, REARED IN
 THE LABORATORY¹

HARRY L. COOK
 and
 M. ALICE MURPHY,
*Bureau of Commercial Fisheries,
 Galveston, Texas, U. S. A.*

CONTENTS

	Page
I. INTRODUCTION.....	109
II. METHODS AND MATERIALS.....	110
III. DESCRIPTION OF STAGES.....	110
A. Egg.....	110
B. Nauplius I.....	110
C. Nauplius II.....	111
D. Nauplius III.....	111
E. Nauplius IV.....	111
F. Nauplius V.....	111
G. Protozoeca I.....	112
H. Protozoeca II.....	115
I. Protozoeca III.....	115
J. Mysis I.....	117
K. Mysis II.....	118
L. Mysis III.....	119
M. Mysis IV.....	122
N. Postlarva I.....	123
IV. CHRONOLOGY OF LARVAL DEVELOPMENT.....	123
V. COMPARISON WITH DEVELOPMENT OF OTHER <i>Sicyonia</i>	123
VI. SUMMARY.....	126
VII. LITERATURE CITED.....	126

ABSTRACT

Five naupliar, three protozoecal, four mysis, and the first postlarval stages of the rock shrimp, *Sicyonia brevirostris* Stimpson, reared from eggs spawned in the laboratory, are described and illustrated.

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I. INTRODUCTION

Fishery scientists at the Bureau of Commercial Fisheries Biological Laboratory in Galveston, Texas are studying the early life histories of Gulf of Mexico Penaeidae as part of an overall effort to establish relationships between the oceanic environment and the populations of commercially important shrimps. The effects of such variables as

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temperature, salinity, and circulation, as well as the success of spawning, cannot be accurately assessed until specific identification of the various larvae is possible. The larvae of penaeid shrimps, especially during the naupliar stage, are remarkably similar, and at least 13 penaeid species occur in the northwestern Gulf of Mexico. To insure accurate identification of those larvae belonging to the genus *Penaeus*, the group of primary importance, we must also be able to distinguish the larval stages of associated non-commercial penaeids. This report describes the early development stages of one of these species, *Sicyonia brevirostris* Stimpson.

According to Lunz (1957), *S. brevirostris* occurs on the continental shelf of the western Atlantic from just south of Norfolk, Virginia, around the Gulf of Mexico to Yucatan. It appears to be confined inside the 50-fathom contour, reaching greatest abundance at 35 to 40 fathoms. At points throughout its range, this shrimp occurs in considerable numbers. It is not fished commercially, but since it has a very agreeable taste and attains a relatively large size, it is generally regarded as having potential commercial value.

II. METHODS AND MATERIALS

All descriptions and figures are from specimens reared in the laboratory. Gravid females were caught at sea and transported to the laboratory. Spawning took place in a fiberglass aquarium that contained 80 liters of aerated, noncirculating sea water. The larvae were then maintained in the aquarium until the first postlarval stage was reached. Cultures of a diatom, *Skeletonema* sp., were added as food at the first protozoal stage and brine shrimp, *Artemia* sp., were introduced at the first mysis stage.

Temperatures during rearing varied between 21.0° and 24.6° C. Salinity, which was 24.5‰ at the start, rose to a maximum of 27.4‰. The pH varied from 8.06 to 8.20.

Samples of larvae to be used for descriptive purposes were taken periodically and preserved in 5% buffered formalin. The unstained larvae were illustrated with the aid of a Camera Lucida. Dissection of the appendages was performed in formalin on a plastic slide.

The figures illustrating each substage depict an average larva. With the exception of the naupliar and protozoal antennae, the

appendages on these figures are intended to show only relative size and position, not setation or segmentation. To illustrate morphological details that would otherwise be obscured, we rotated the antennae of the naupliar substages on their axes. Figures of the mouth parts and other appendages represent a single appendage taken from one individual. In order to present a clearer figure, the setules on the setae were usually omitted. Measurements are given in mm.

The following abbreviations are used in the text: TL = total length, including the rostrum but excluding the caudal spines; W = mean width at the point of greatest width; CL = carapace length, including the rostrum; N = number of specimens.

The adult from which the larvae were obtained was identified according to Anderson and Lindner (1943) and Lunz (1945). Both the adult and the larvae have been deposited in the museum of the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas.

III. DESCRIPTION OF STAGES

A. Egg (Fig. 1)

Viable eggs of *S. brevirostris* are round, golden brown in color, and translucent. Eggs measured soon after spawning were 0.23 mm in diameter. As the nauplius developed within the egg, the diameter increased to 0.27 mm just prior to hatching.

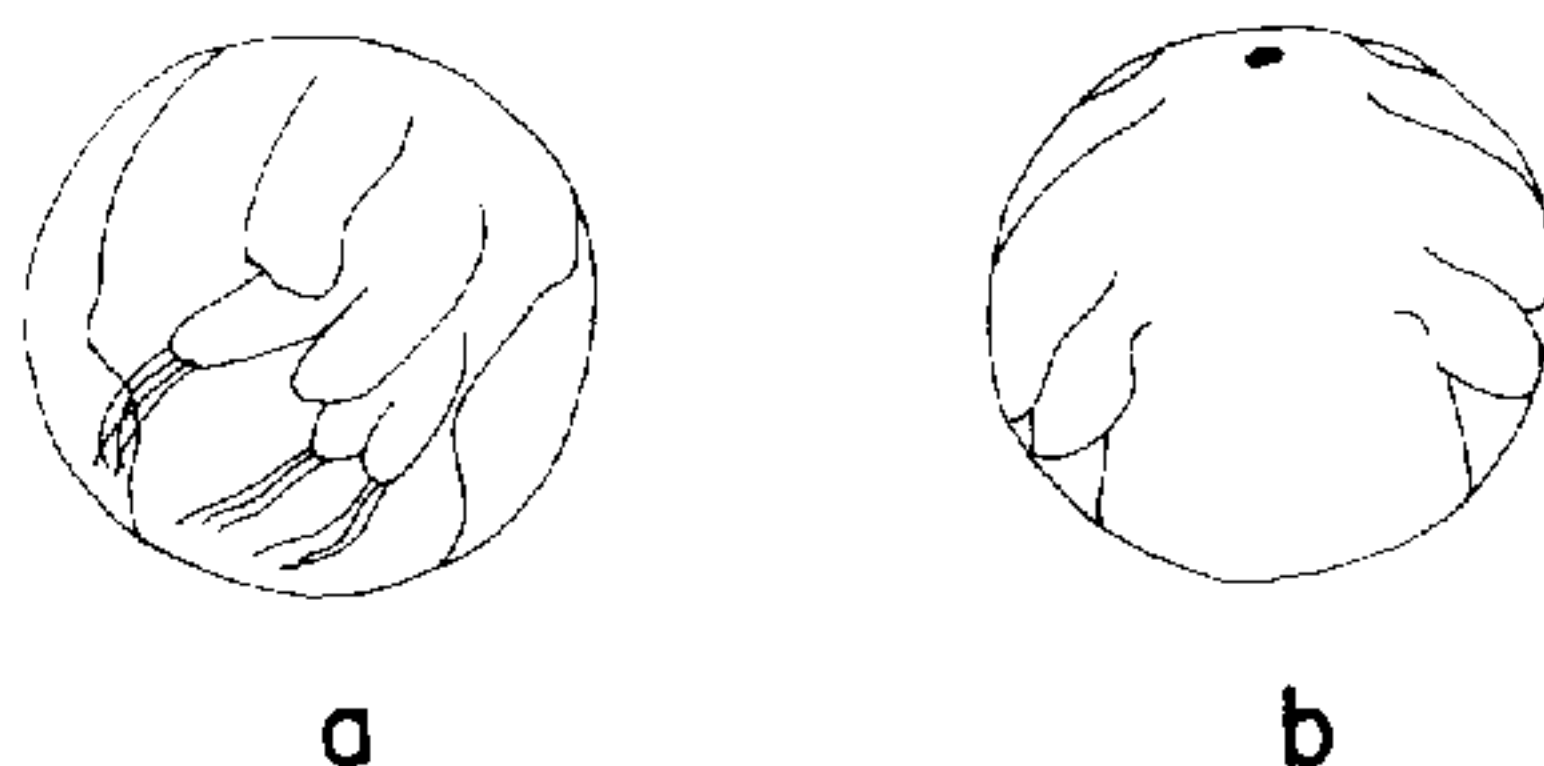


Figure 1. Late eggs showing developing nauplii. a. lateral view b. ventral view.

Hatching was observed only once. The nauplius filled the egg case and the furcal spines were already protruding when it was first noted. The nauplius appeared to flex, straightening out the first and second appendages and pushing the eggshell off the anterior end of its body.

B. Nauplius I (Fig. 2)

Mean TL = 0.30 mm (0.28-0.32 mm);

W = 0.17 mm; N = 10

Nauplii of *S. brevirostris* exhibit the pyri-

form body that is typical of all penaeid larvae thus far described. A blunt labrum is present on the ventral surface and a slight protuberance arises from the dorsal surface of the body.

An ocellus, which is retained in subsequent naupliar substages, lies on the longitudinal axis of the body near the anterior end.

The posterior end of the body is rounded and bears a pair of spines.

Three pairs of appendages arise from the anterior portion of the body. The anterior ones (first antennae) are unbranched. The middle pair (second antennae) and third pair (mandibles) are branched into ventral endopods and dorsal exopods.

Setae arising from the appendages are smooth, but in succeeding substages the longer ones become plumose.

Color of the body and appendages is golden brown. The ocellus is black. Notes on color were not made for succeeding stages.

Setation of appendages:

First Antenna: Two short ventrolateral; a short spike and two long terminal; one long dorsolateral.

Second Antenna:

Endopod: Two short ventrolateral; two long terminal.

Exopod: Three long ventrolateral; two long terminal.

Mandible: Both branches bear three long setae.

C. *Nauplius II* (Fig. 3)

Mean TL = 0.31 mm (0.29-0.34 mm);

W = 0.18 mm; N = 7

The body is slightly more elongate than in the preceding substage. The posterior portion (edge) of the body between the single pair of caudal spines becomes flattened.

Setation of appendages:

First Antenna: Two short ventrolateral; one short, one long, and one medium terminal; one short dorsolateral.

Second Antenna:

Endopod: Two short ventrolateral; two long terminal.

Exopod: Three long ventrolateral; two long and one short terminal.

Mandible: Unchanged from Nauplius I.

D. *Nauplius III* (Fig. 4)

Mean TL = 0.35 mm (0.32-0.37 mm);

W = 0.18 mm; N = 26

The body is more elongate than in Nauplius II. Faint folds, the beginnings of ventral appendages, can be seen posterior to the labrum. The bases of the mandibles have become slightly swollen. A depression is present between the three pairs of caudal spines.

Setation of appendages:

First Antenna: One short and two medium ventrolateral; one medium, one long, and one short terminal.

Second Antenna:

Endopod: Two short ventrolateral; one short and two long terminal.

Exopod: Four long ventrolateral; two long and one short terminal.

Mandible: Unchanged from Nauplius I.

E. *Nauplius IV* (Fig. 5)

Mean TL = 0.37 mm (0.33-0.40 mm);

W = 0.18 mm; N = 30

The body has become longer and the posterior portion more slender. The ventral appendages that were first noted in the preceding substage are more prominent, though still beneath the cuticle. These are the first and second maxillae and first and second maxillipeds. Two definite lobes have been formed at the posterior end of the body, each bearing five caudal spines.

Setation of appendages:

First Antenna: Two long and one medium ventrolateral; two long and one short terminal; one short dorsolateral.

Second Antenna:

Endopod: Two short ventrolateral; one long and two medium terminal.

Exopod: One medium and three long ventrolateral; two long, one medium, and one short terminal.

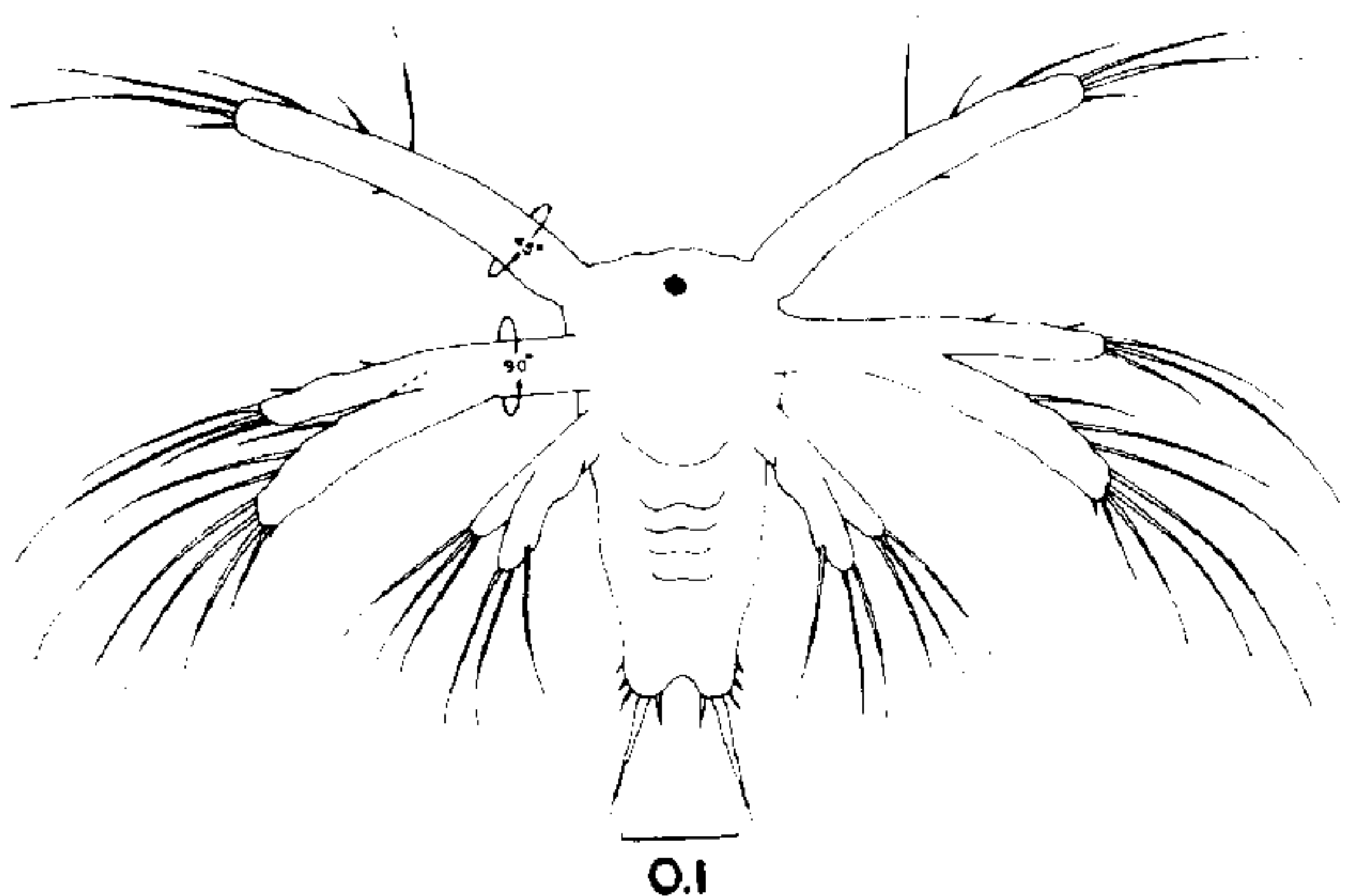
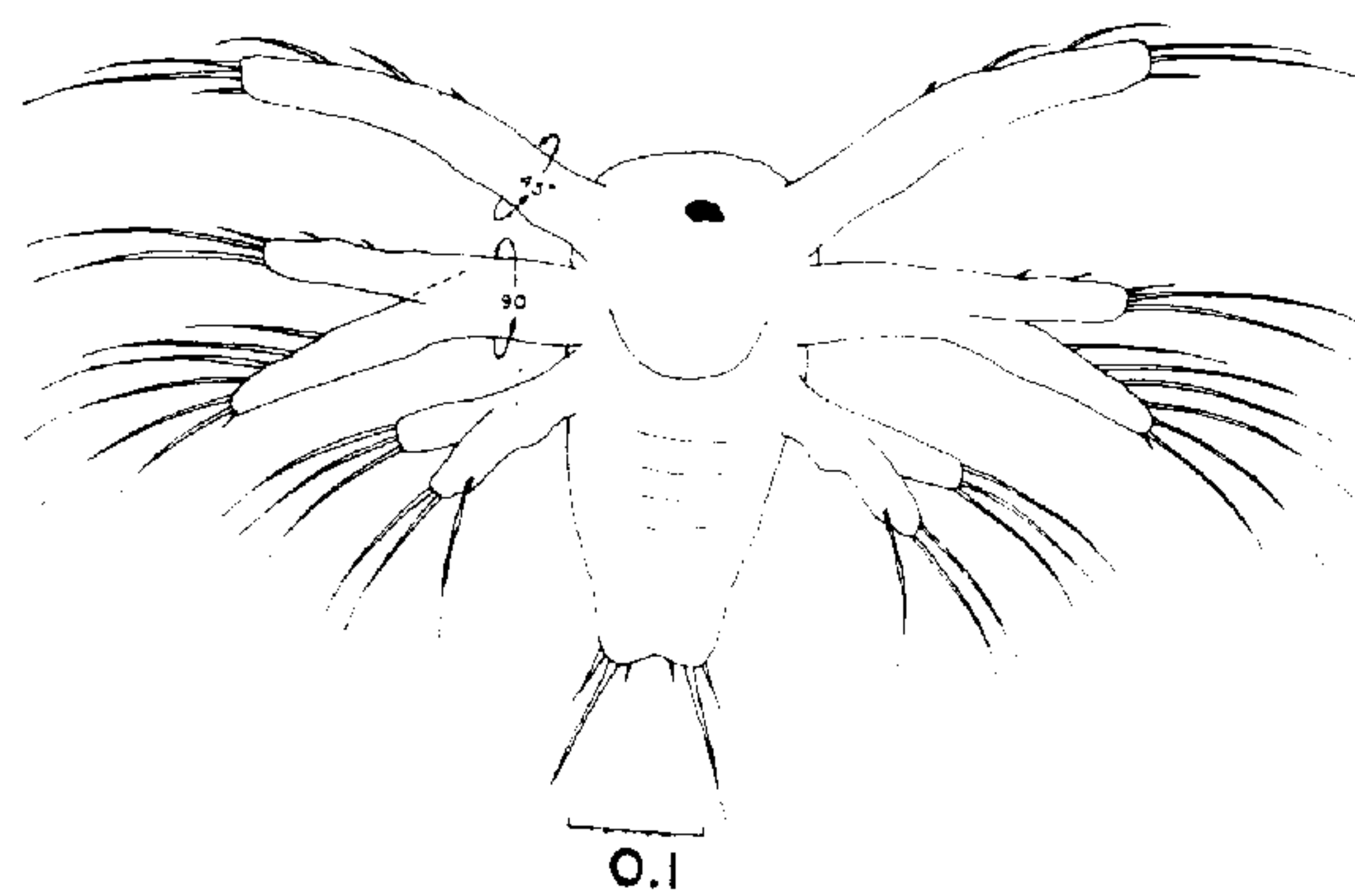
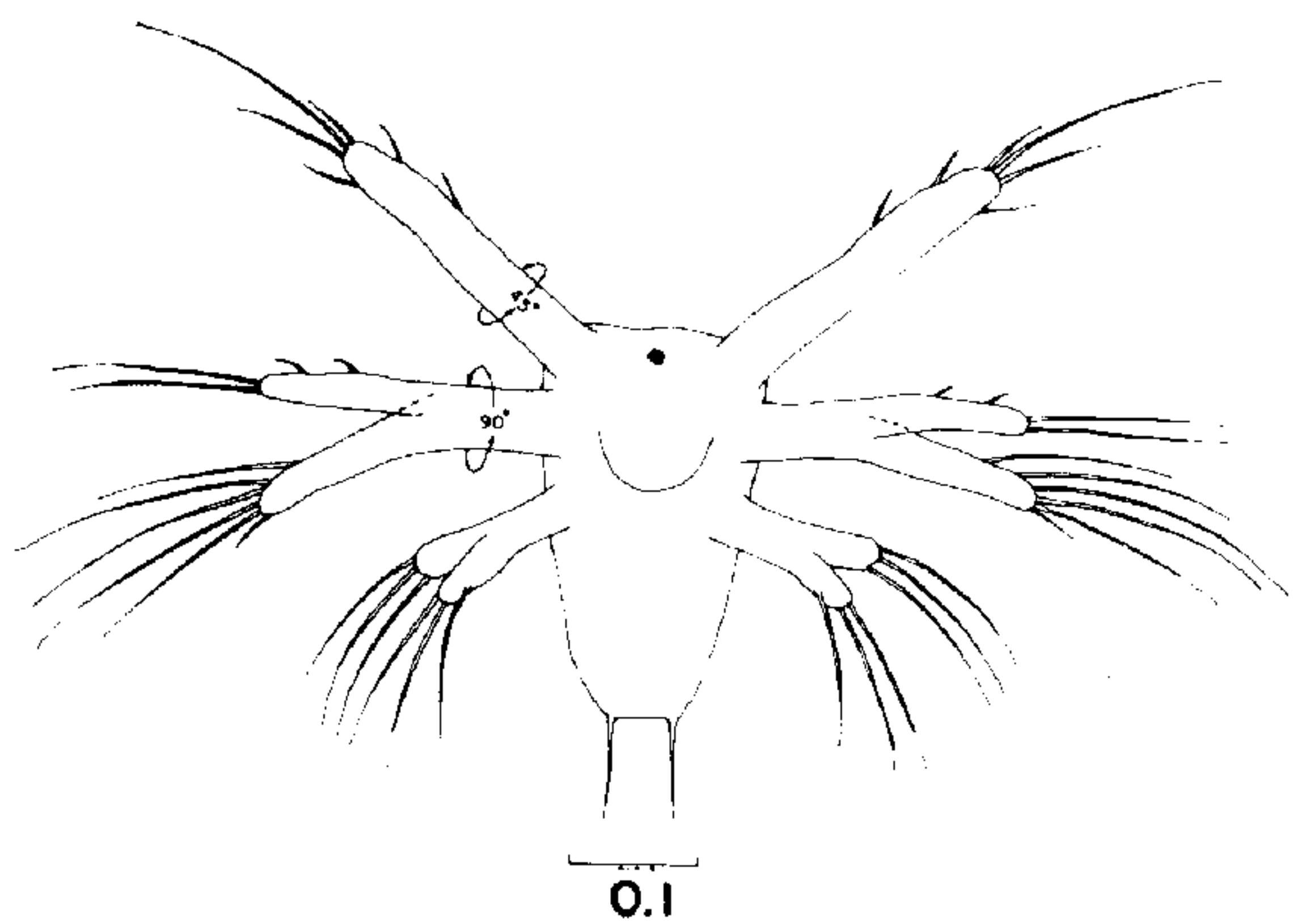
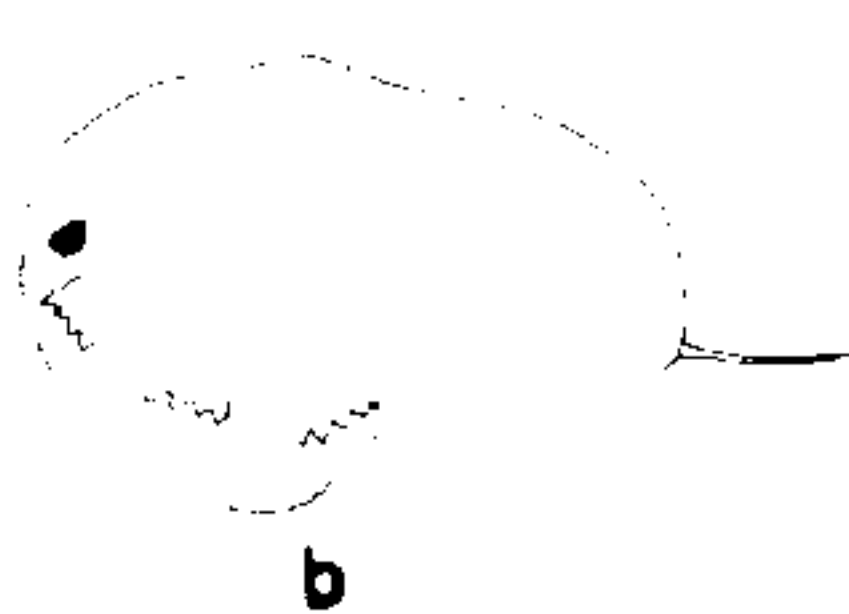
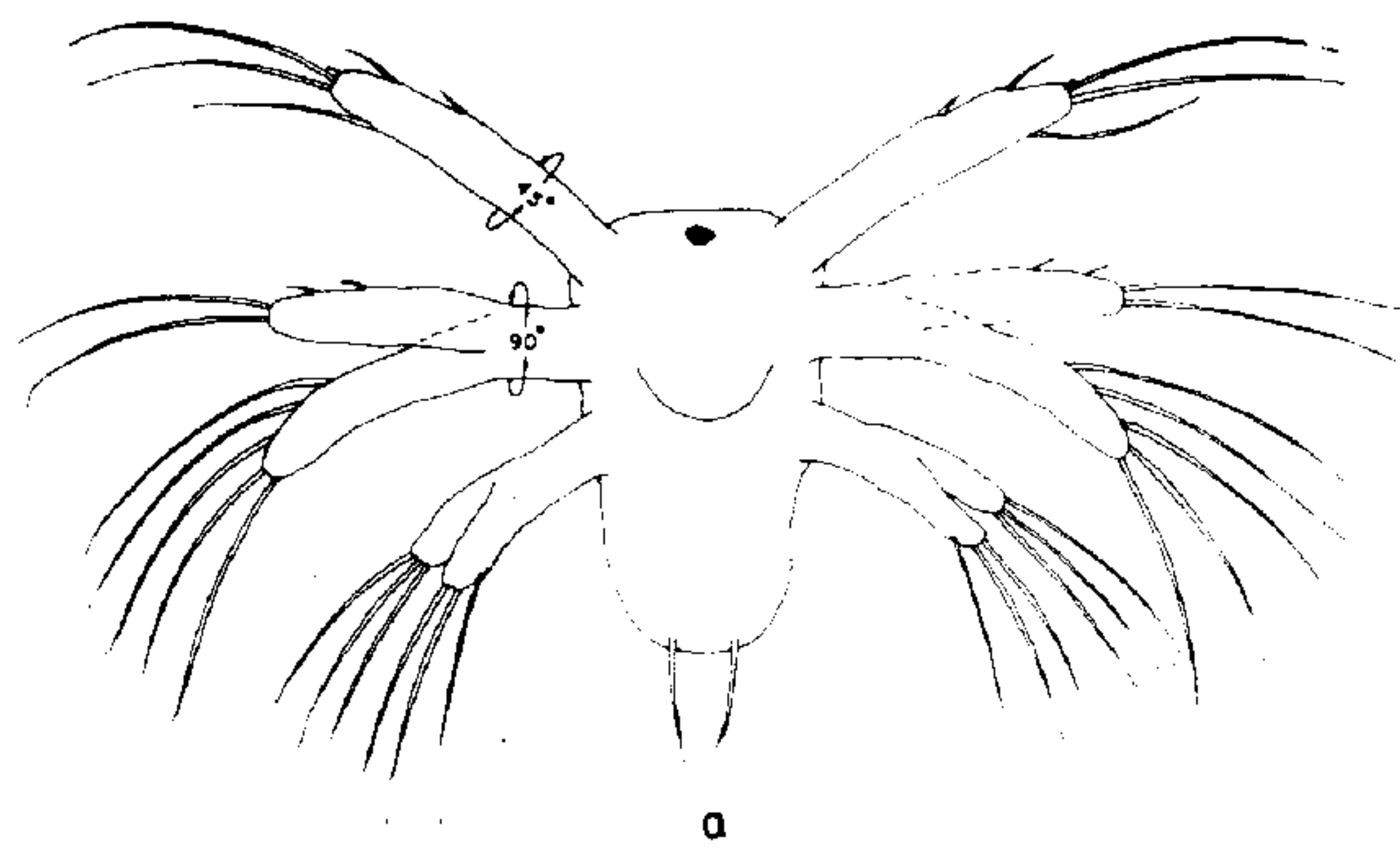
Mandible: Unchanged from Nauplius I.

F. *Nauplius V* (Fig. 6)

Mean TL = 0.44 mm (0.38-0.46 mm);

W = 0.18 mm; N = 46

The body is further elongated and the furcal processes are more pronounced, each giving rise to seven spines. The maxillae and maxillipeds are now external, and show more advanced development. The swelling at the base of the mandible, which has become large and prominent, possesses a masticatory surface composed of several rows of small teeth. Both the endopod and exopod of the mandible are frequently hollow and transparent. The outline of a developing carapace



Figures 2-5, top to bottom. 2. Nauplius I. a. ventral view b. lateral view. 3. Nauplius II, ventral view. 4. Nauplius III, ventral view. 5. Nauplius IV, ventral view.

can be seen on the dorsal surface of the body, and frontal organs are present on its anterior margin.

Setation of appendages:

First Antenna: Two short and one medium ventrolateral; two long, one medium, and two short terminal; two short dorso-lateral.

Second Antenna:

Basis: One short ventrolateral.

Endopod: Two medium and two short ventrolateral; one short and three long terminal.

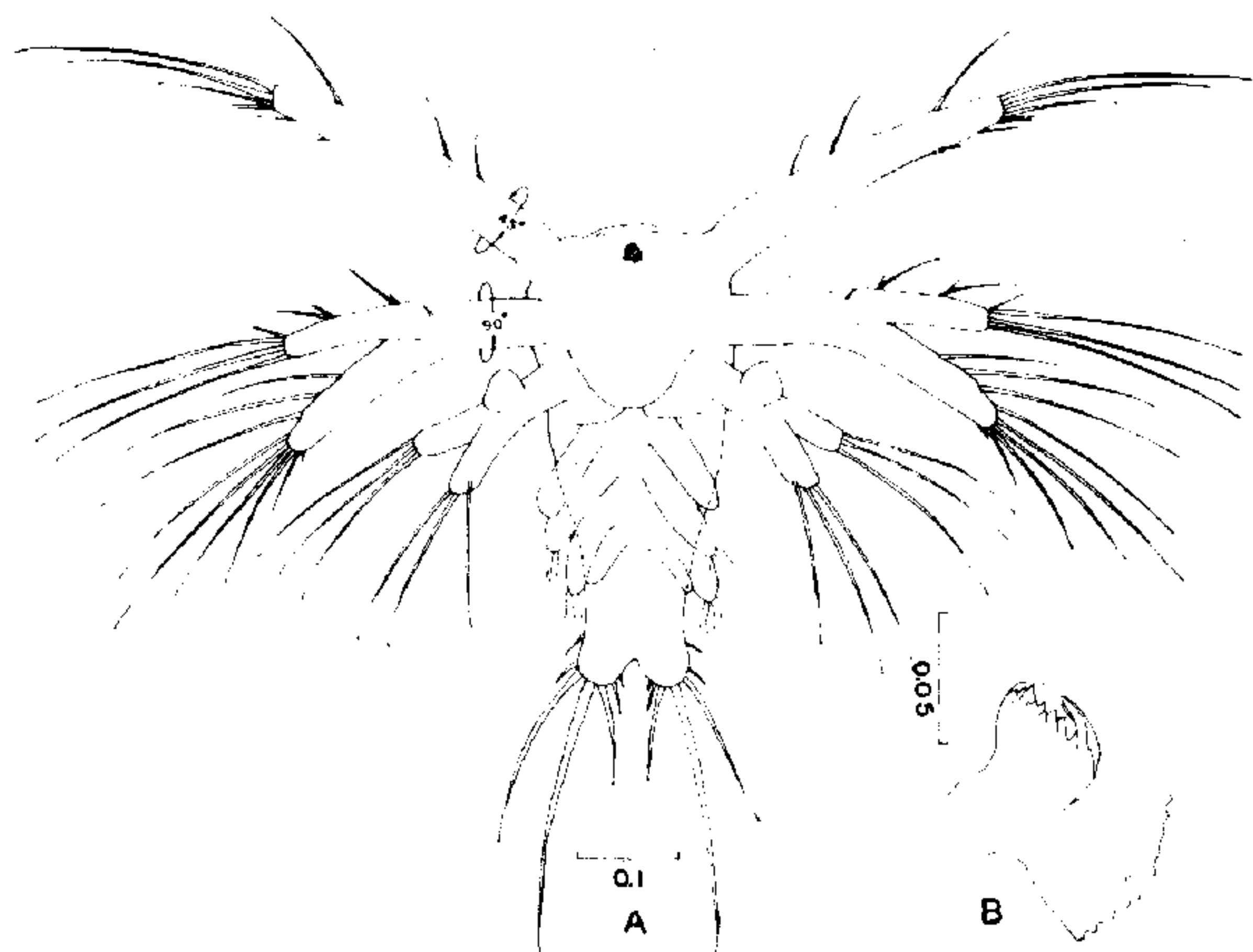


Figure 6. Nauplius V. A. ventral view B. base of mandible.

Exopod: Four long ventrolateral; three long, one medium, and one short terminal.

Mandible: Unchanged from Nauplius I.

G. *Protozoa I* (Fig. 7)

Mean TL = 0.81 mm (0.70-0.99 mm);

mean CL = 0.33 mm (0.30-0.36 mm);

N = 39

Body shape changes considerably with the molt to the first protozoal substage. A large, loose-fitting carapace covers the anterior section of the body. The posterior portion of the body has lengthened greatly and is now distinctly segmented. The maxillae and first and second maxillipeds are well developed and functional.

The carapace is rounded with a median notch at the anterior end, a pair of rounded frontal organs being the only protuberances on it. The ocellus, which persists in subsequent protozoal substages, is present between a pair of compound eyes that are visible beneath the carapace. The labrum does not bear a spine on its anterior margin. Two lobes of the labium, bearing short bristles on their inner margins, can be seen posterior to the labrum. Several teeth of the

inwardly projecting mandibles can be seen between the labrum and labium.

The first antenna is approximately twice the length of the endopod of the second antenna. It is composed of three major segments. The basal segment, which is divided into five subsegments, bears one short seta. The second segment bears three setae, one short and one medium ventrolateral, and one

short posterolateral. The disal segment bears three long and two short terminal, and one short posterolateral, setae.

The second antenna is composed of a two-segmented protopod, an endopod of two segments, and an exopod of from seven to nine, frequently indistinct, segments. The protopod bears one seta at the juncture with the endopod. The first segment of the endo-

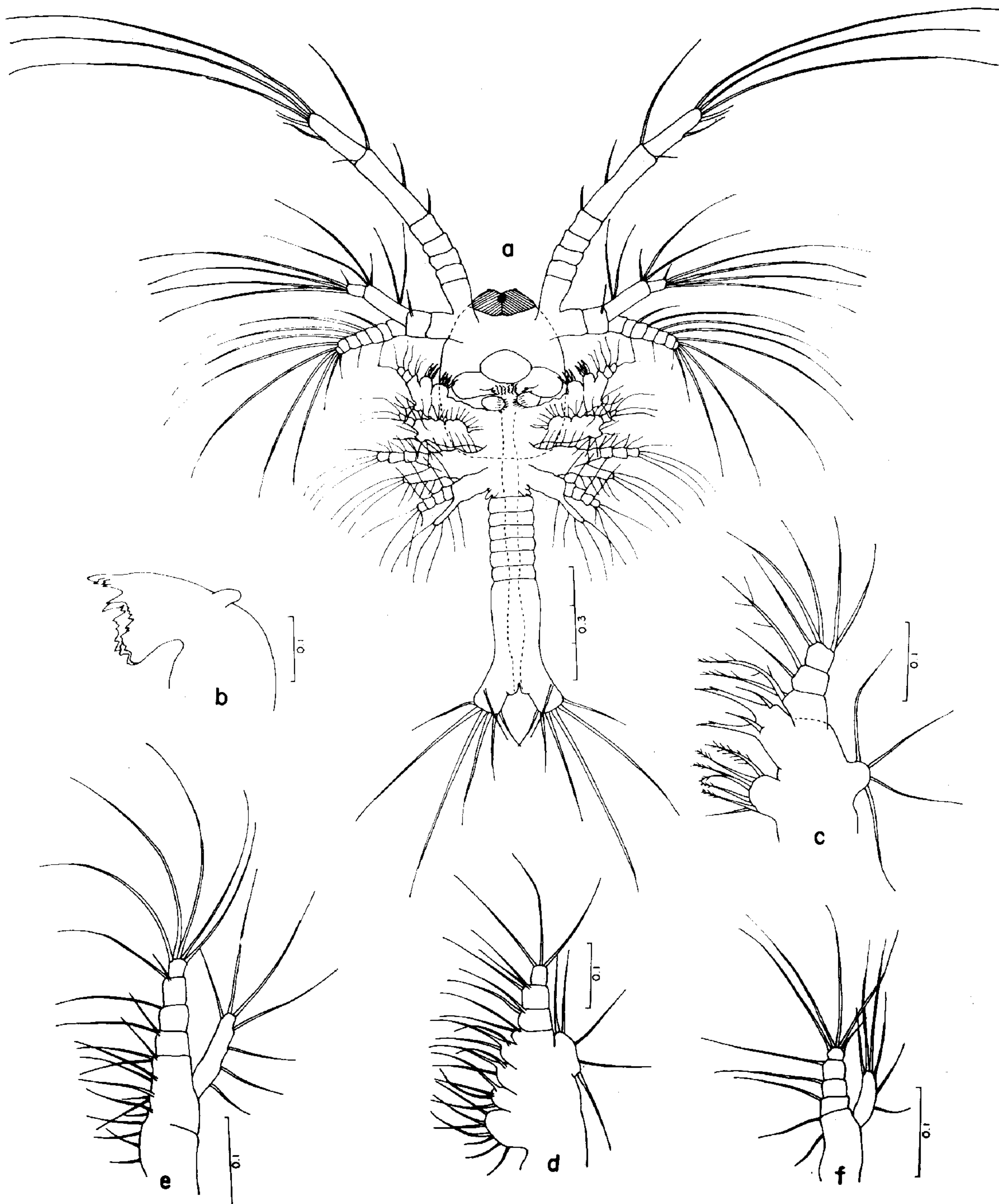


Figure 7. Protozoa I.

a. Ventral view
b. Mandible

c. Maxilla I
d. Maxilla II

e. Maxilliped I
f. Maxilliped II

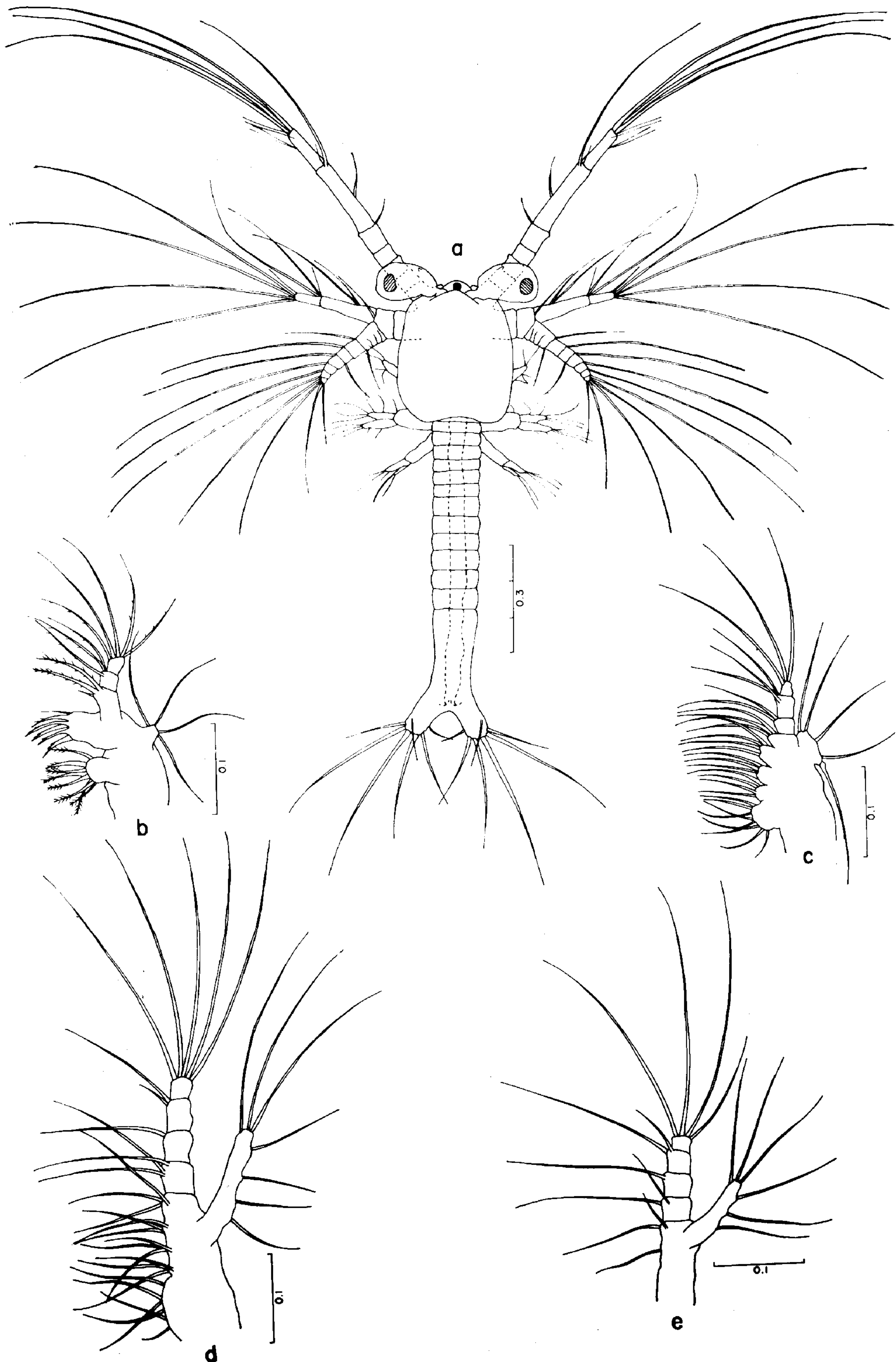


Figure 8. Protozea II.

a. Dorsal view
b. Maxilla I

c. Maxilla II
d. Maxilliped I

e. Maxilliped II

pod gives rise to a pair of setae from a point about one-third the length of the segment, and three terminal setae. The distal segment bears five terminal setae. The exopod bears five setae on its ventrolateral and two on its dorsolateral margins, as well as five terminal setae.

The mandible has lost both the endopod and exopod. The masticatory process is longer than in the last naupliar substage and curves inward, terminating in a ring of teeth.

The first maxilla consists of an unsegmented protopod, a three-segmented endopod, and a small knoblike exopod. The protopod has two large lobes, each giving rise to several stout, toothed spines. The first and second segments of the endopod each bear two setae, and the third five. The exopod bears four setae.

The second maxilla is comprised of an unsegmented protopod, a three-segmented endopod and a small knoblike exopod. The protopod has five lobes on its ventral margin, the basal lobe bears about seven setae and the remainder two to five. The first segment of the endopod bears two setae, the second and third, three; the exopod bears five.

The first maxilliped is longer than the maxillae and is biramous. It is composed of an unsegmented protopod, a four-segmented endopod, and an unsegmented exopod. The protopod has from 13 to 15 setae on its ventral margin. The first and third segments of the endopod each bear two setae; the second, one; and the fourth, five. The exopod bears four lateral and three terminal setae.

The second maxilliped greatly resembles the first, although it is somewhat smaller. The protopod bears two setae. The first three segments of the endopod each bear one seta and the fourth bears five. The exopod has three lateral and three terminal setae.

The third maxilliped is small, biramous, and usually does not bear setae.

The slender posterior portion of the body is divided into six thoracic segments and an unsegmented abdomen. The abdomen terminates in a well-developed, forked, telson, each lobe of which bears seven spines, the outermost extending inward across the furca.

H. *Protozoaea II* (Fig. 8)

Mean TL = 1.23 mm (1.12-1.44 mm);

mean CL = 0.44 mm (0.38-0.45 mm);

N = 28

The second protozoaea is characterized by the presence of stalked compound eyes, a segmented abdomen, and a small rostrum which does not extend to the anterior edge of the body.

The frontal organs have been lost and do not reappear in later substages. Small papillae which are present on the dorsoanterior margins of the eyes persist in the third protozoal substage.

Segmentation of the appendages remains almost unchanged from the preceding substage. A dorsolateral seta has been added to the terminal segment of the first antenna. The number of spines on the second lobe of the protopod of the first maxilla has increased and an additional short seta is found on both the first and second segments of the endopod. Three setae have been added to the second maxilliped, one on the protopod and two on the endopod. Rudiments of five pairs of pereopods are present posterior to the maxillipeds.

The abdomen is divided into six segments with the telson still part of the sixth. The number of caudal spines remains constant at seven pairs.

I. *Protozoaea III* (Fig. 9)

Mean TL = 1.96 mm (1.84-2.09 mm);

mean CL = 0.58 mm (0.54-0.61 mm);

N = 20

This substage can be distinguished from the second protozoaea by the presence of biramous uropods and spines on the abdominal segments.

The rostrum has undergone slight elongation and now extends slightly past the anterior margin of the body.

The five subsegments which made up the basal segment of the first antenna in preceding protozoal substages have combined and three are now four segments. The first segment gives rise to one seta; the second and third, two; and the fourth, seven. In addition to the two more prominent setae, a variable number of small setae now rim the distal portion of the third segment.

The second antenna, maxillae, and second and third maxillipeds remain essentially the same as in the preceding substage. The seta on the second segment of the endopod of

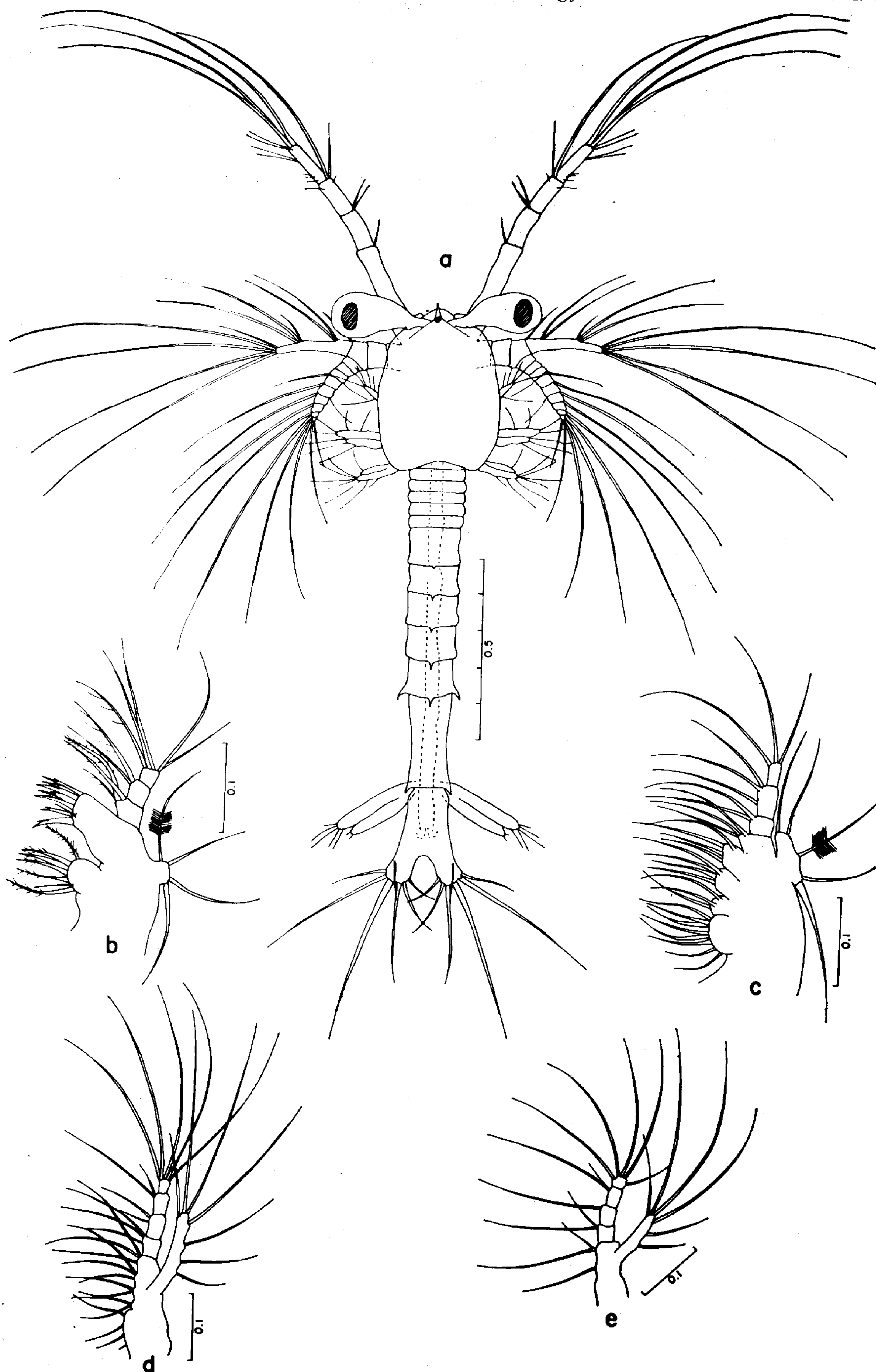


Figure 9. Protozoaea III.

a. Dorsal view
b. Maxilla I

c. Maxilla II
d. Maxilliped I

e. Maxilliped II

the first maxilla in the preceding substage has been lost. Such condition might indicate a variable number of setae on this segment. A second seta is present on the second segment of the endopod of the first maxilliped. Although the pereopods have developed further and are biramous, they are still non-functional.

Segmentation of the abdomen is more distinct in this substage. Each of the first five segments bears a median spine on its dorso-posterior border. The fifth segment also has a pair of posterolateral spines, as does the sixth.

The telson is now separated from the sixth segment and each lobe retains seven caudal spines. A pair of biramous uropods originate from the ventroanterior margin of the telson. The exopod is slightly longer than the endopod and five or six setae arise from its apex. The endopod usually has two very small terminal setae.

J. *Mysis I* (Fig. 10)

Mean TL = 2.47 mm (2.16-2.66 mm);

mean CL = 0.82 mm (0.74-0.89 mm);

N = 24

At the molt to the first mysis substage, the larva undergoes another fundamental modification in body form, taking on a semblance of the adult for the first time. The transfiguration is exemplified in the functional pereopods with their long brushlike exopods, and by the transformation of the first and second antennae into the adult shape.

The carapace has a short rostrum that extends slightly less than half the length of the eye. A single spine is found on the dorsal carina of the carapace. Supraorbital and pterygostomial spines are present.

The ocellus and ocular papillae persist in this and succeeding mysis substages.

The first antenna consists of three segments. The first segment, which is about twice the length of the second and third combined, bears two spines, one on its median margin, and one on its lateral margin. The distal segment gives rise to two branches; the lateral, bearing five or six setae, is three times as long as the median, which bears a single seta. A series of setae are present along the margins of the appendage, and numerous setae arise from the apex of each segment.

The second antenna is composed of a two-

segmented protopod (the basal segment is not shown in fig. 10), an unsegmented endopod with two lateral and three terminal setae, and an unsegmented, flattened exopod which bears 10 setae along its median and apical margins as well as a single, subterminal, externolateral seta.

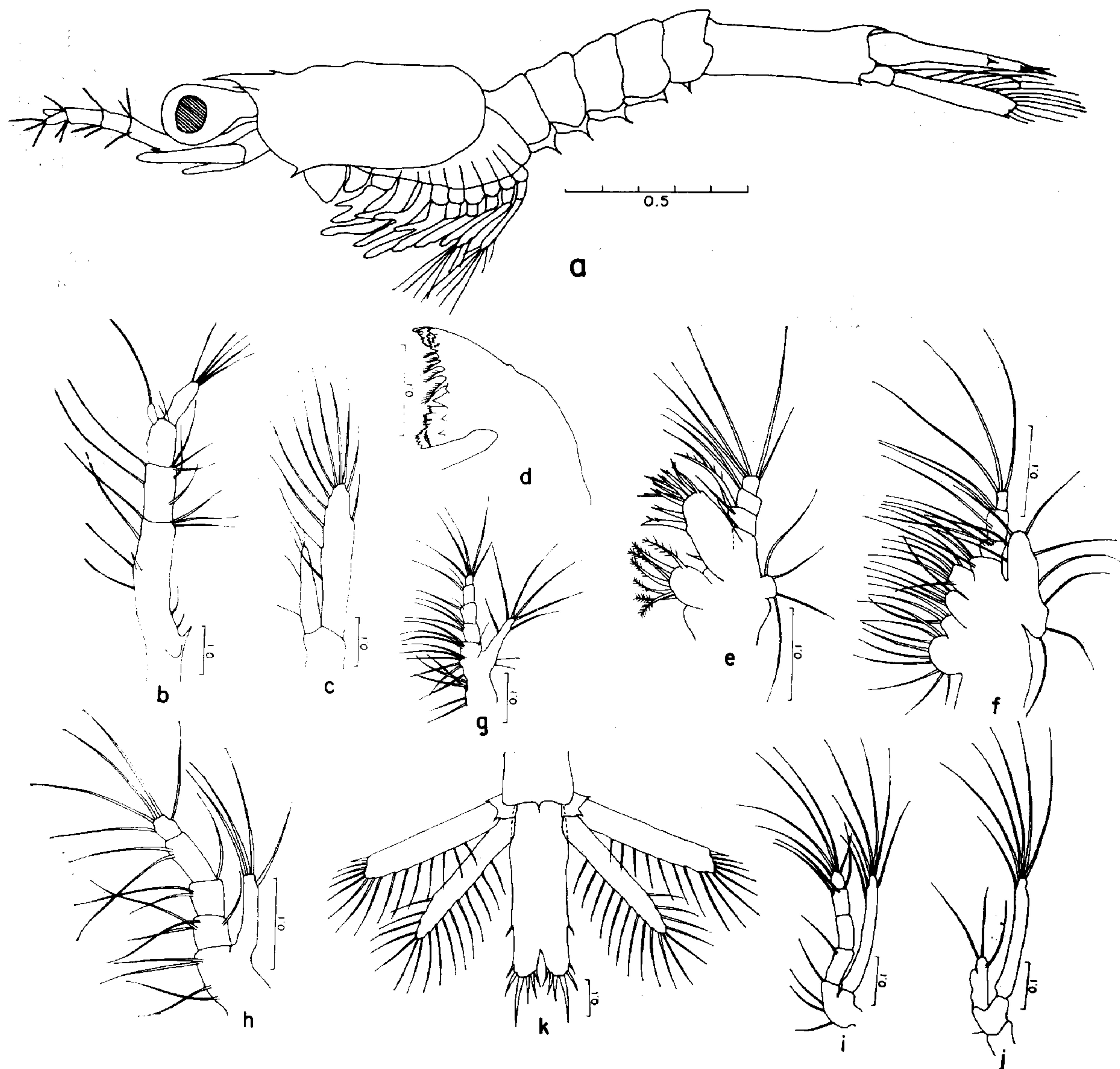
The mandible has undergone no appreciable change. A short spine, added at the base of the second lobe of the protopod of the first maxilla, is the only difference. The exopod of the second maxilla has enlarged and now bears nine setae. An additional seta is present at both the apex of the protopod and on the endopod of the first maxilliped. The first and second segments of the endopod of the second maxilliped have each gained two setae, and two lateral setae have been lost from the exopod.

The third maxilliped and five pereopods have become enlarged and possess long unsegmented exopods which bear six to eight setae. The protopod of the third maxilliped is unsegmented and bears four setae. Its endopod is composed of four segments, the first giving rise to one seta; the second, none; the third, three; and the fourth, five. The protopod of the first pereopod is two-segmented with only a single seta present on the second segment. The endopod of the first pereopod has been modified to form a rudimentary chela bearing three setae. The other four pereopods were not examined in detail.

A ventromedian spine arises from each of the first five abdominal segments; the pleura, however, normally do not bear spines. Infrequently, laboratory-reared mysis exhibited dorsoposterior spines on the fourth, fourth and fifth, or fifth segments. Since examination of *Sicyonia* mysis from the plankton has failed to yield a specimen with dorsoposterior spines, their presence is tentatively regarded as an abnormal condition. The sixth segment possesses a dorsomedian spine and a pair of posterolateral spines.

The uropod has developed an unsegmented protopod which bears a posteroventral and a posterolateral spine. The endopod and exopod are of equal length and bears numerous setae on their margins.

The telson, deeply cleft, bears six pairs of terminal and subterminal spines, and a single pair of lateral spines.

Figure 10. *Mysis I*.

- a. Lateral view
- b. Antenna I
- c. Antenna II
- d. Mandible

- e. Maxilla II
- f. Maxilla II
- g. Maxilliped I
- h. Maxilliped II

- i. Maxilliped III
- j. Periopod I
- k. Telson

K. *Mysis II* (Fig. 11)

Mean TL = 2.89 mm (2.70-3.15 mm);

mean CL = 0.96 mm (0.90-1.05 mm);

N = 13

A second spine is added to the dorsal carina of the carapace and there is now a well-developed antennal spine.

The first antenna remains unchanged, except that the developing statocyst can now be seen at the base of the appendage. The exopod of the second antenna now possesses a subterminal spine on its lateral margin and the number of median and apical setae has increased to 13.

The mandible bears a large unsegmented palp. An exopod is no longer present on the first maxilla, and a seta has been lost from the second segment of the endopod. The endopod of the second maxilla has become further enlarged and the number of setae has increased to 24.

The protopods of the three maxillipeds are composed of two segments. The terminal seta added to the protopod of the first maxilliped in the last substage is no longer present. The first segment of the endopod has also lost a seta. The endopod of the second maxilliped has gained a terminal seta.

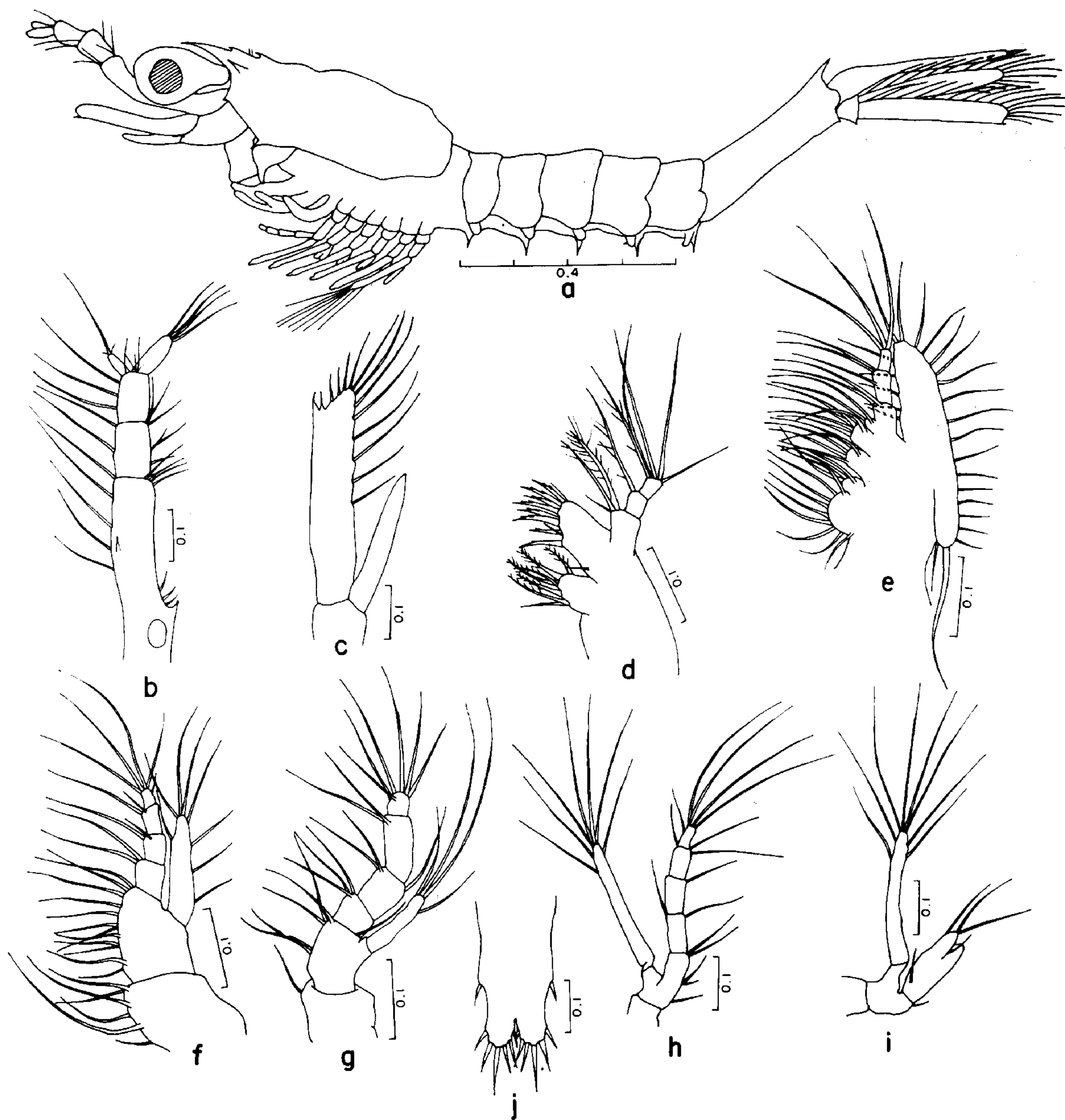


Figure 11. Mysis II

- a. Lateral view
- b. Antenna I
- c. Antenna II
- d. Maxilla I

- e. Maxilla II
- f. Maxilliped I
- g. Maxilliped II
- h. Maxilliped III

- i. Pereiopod I
- j. Telson

A single seta has been added to both the first and second segments of the endopod of the third maxilliped. The chela of the first pereopod now bears six setae. Rudiments of the branchiae are present as small lobes on the maxillipeds and pereopods.

The addition of small unsegmented pleopods and a reduction in the width of the cleft in the telson represent the only major changes in the posterior portion of the body.

L. *Mysis III* (Fig. 12)

Mean TL = 3.51 mm (2.94-3.72 mm);
mean CL = 1.13 mm (0.90-1.26 mm);
N = 18

An additional spine added to the dorsal carina of the carapace raises the count to three.

The antenna have been modified slightly; the basal segment of the first antenna has gained a lateral spine apically, the endopod

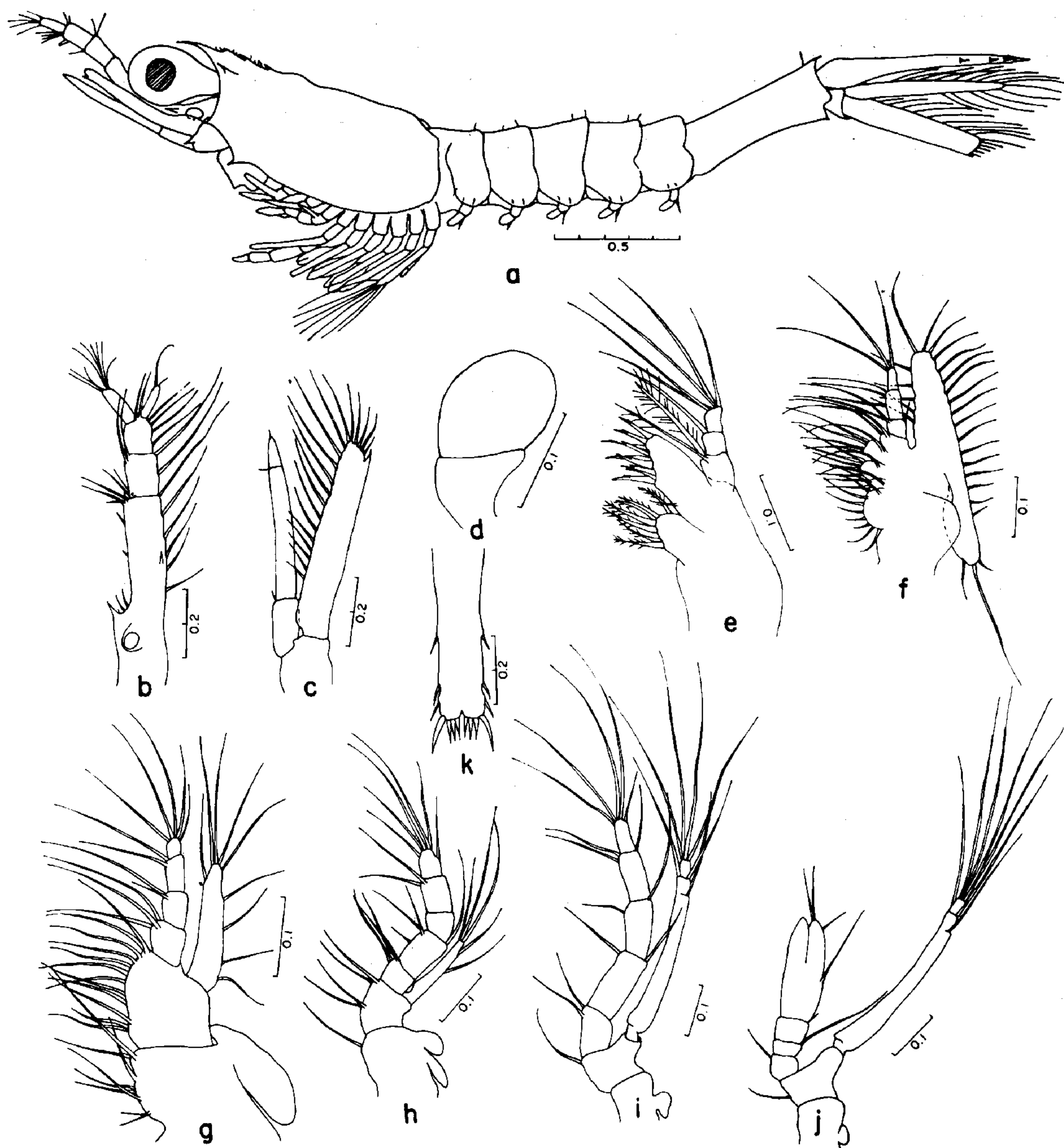


Figure 12. Mysis III.

- a. Lateral view
- b. Antenna I
- c. Antenna II
- d. Mandibular palp

- e. Maxilla I
- f. Maxilla II
- g. Maxilliped I
- h. Maxilliped II

- i. Maxilliped III
- j. Pereiopod I
- k. Telson

of the second antenna is now made up of three segments and its exopod bears 19 setae.

The mandibular palp, composed of two segments, has enlarged further. The maxillae remain essentially unchanged from the preceding substage. Rudiments of the gills are present on the three maxillipeds and first pereiopod.

A seta has been added to both the first segment of the endopod and to the exopod of the first maxilliped. The endopod of the second maxilliped has gained an additional segment which does not bear setae. The dis-

tal segment of its protopod has lost two setae, leaving the protopod with one seta, while the exopod and the second segment of the endopod each have an additional seta. The endopod of the third maxilliped has gained a segment, making a total of five. The first three segments of the endopod now possess two setae each; the fourth segment, three; and the fifth, five. The exopod of the third maxilliped and of each pereiopod is now composed of two segments. The endopod of the first pereiopod is composed of four segments, with the distal segment being the

rudimentary chela.

The posterior portion of the body has changed little. The pleopods, although now two-segmented, are still small. The cleft in the telson has become greatly reduced in size

and the position of the spines has changed. There are now four pairs of terminal and three pairs of lateral spines. The postero-ventral spine on the protopod of the uropod is absent.

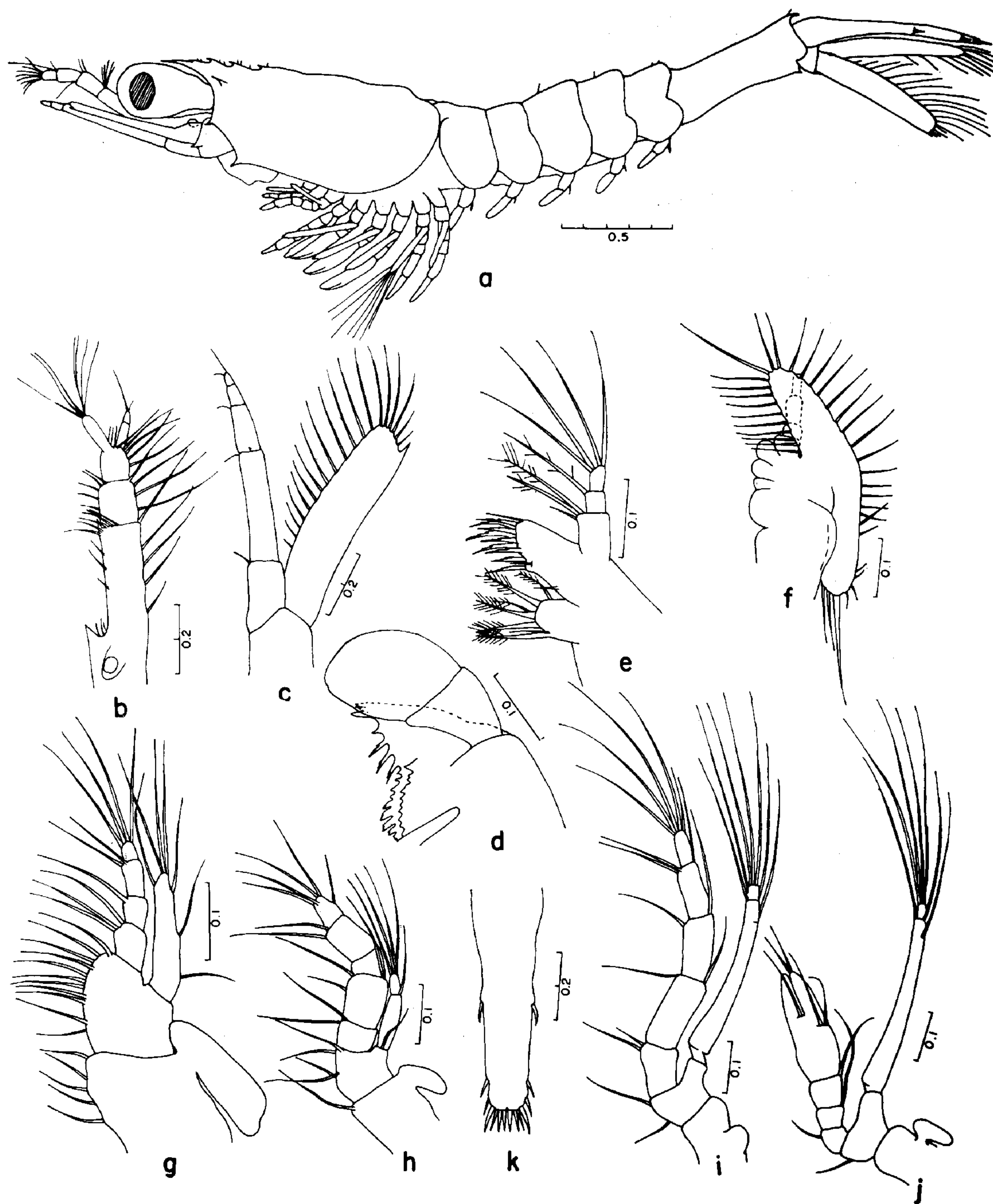


Figure 13. Mysis IV.

- a. Lateral view
- b. Antenna I
- c. Antenna II
- d. Mandible

- e. Maxilla I
- f. Maxilla II
- g. Maxilliped I
- h. Maxilliped II

- i. Maxilliped III
- j. Periopod I
- k. Telson

M. Mysis IV (Fig. 13)
 Mean TL = 3.68 mm (3.48-3.81 mm);
 mean CL = 1.20 mm (1.11-1.23 mm);
 N = 10

The fourth mysis differs only slightly from the preceding substage. The addition of a fourth rostral spine and a reduction in the cleft of the telson represent the most prominent modifications. The antennae have also undergone changes, with the endopod of the first antenna now composed of two segments, and that of the second, five segments.

The distal segment of the endopod of the first maxilla has lost a seta. The number of setae on the exopod of the second maxilla has increased to 36 and, although not shown in Fig. 13f, the setation of the protopod and exopod remains unchanged. The second and fourth segments of the endopod of the first maxilliped have each lost a seta, and the exopod, two. The number of setae on the protopod of the second maxilliped, and that of the second and fifth segments of its endopod, has increased and decreased by

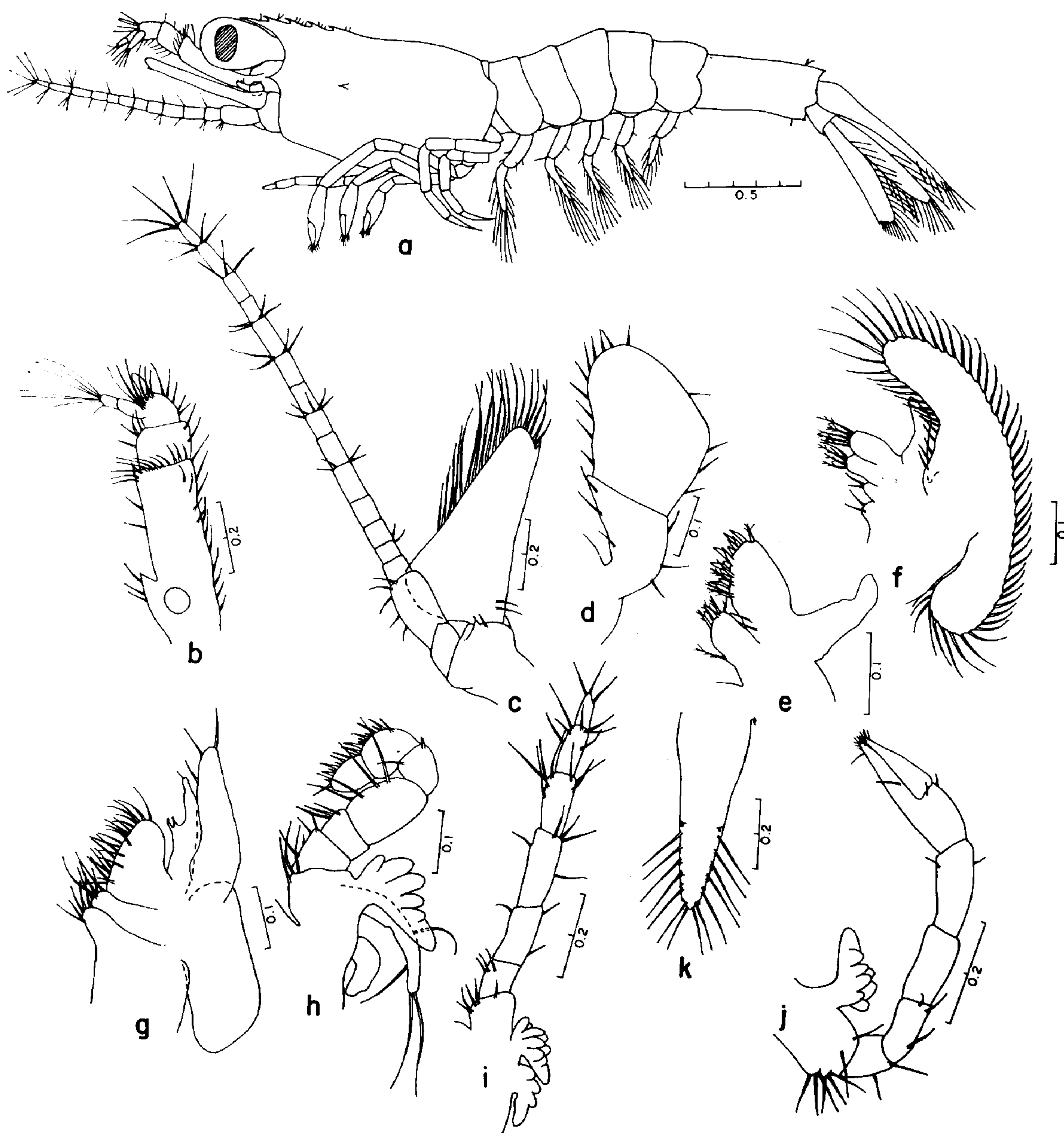


Figure 14. Postlarva I.

- a. Lateral view
- b. Antenna I
- c. Antenna II
- d. Mandibular palp

- e. Maxilla I
- f. Maxilla II
- g. Maxilliped I
- h. Maxilliped II

- i. Maxilliped III
- j. Pereiopod I
- k. Telson

one, respectively; its exopod is now two-segmented.

The pleopods retain essentially the same shape, but have increased in length and are now about one and one-half times the length of those of the previous substage.

N. *Postlarva I* (Fig. 14)

Mean TL = 3.87 mm (3.51-4.35 mm);

mean CL = 1.13 mm (1.07-1.21 mm);

N = 9

With the molt to postlarva, the exopods are lost from the pereopods and the pleopods, now heavily setose, are the principal swimming organs.

The rostrum is short, extending about one-half the length of the eye. The carapace usually bears four teeth on its dorsal carina, although some specimens show a small fifth spine anteriorly. Hepatic and antennal spines are present, the supraorbital and pterygostomian spines having been lost.

The ocellus persists, but the ocular papillae are no longer present.

Although there is no appreciable change in the first antenna, the endopod (flagellum) of the second antenna is elongate and composed of 16 segments, while the exopod (antennal blade) is very broad at its base.

The mandibular palp has increased in size and bears about 20 setae along its margin. The endopod of the first maxilla is reduced greatly and is no longer setose. The endopod of the second maxilla is also vestigial, and the spines on the four lobes of the protopod are less prominent. The exopod has enlarged greatly and possesses about 60 setae.

Both the endopod and exopod of the first maxilliped are greatly reduced in size and setation. The second maxilliped retains a greatly reduced exopod, while the third maxilliped and the pereopods have lost their exopods. The second maxilliped has become recurved and bears numerous spinelike setae on the last two segments. The dactyls of the chelipeds are fully formed. Although still rudimentary, the branchiae on the maxillipeds and pereopods have developed two rows of small protuberances on their external surfaces.

The first five abdominal segments do not possess spines. The sixth segment has a small dorsomedian and a small pair of posterolateral spines.

The uniramous pleopods have lengthened

and bear about 12 setae on the second segment.

The protopod of the uropod retains a small posterolateral spine. The endopod and exopod are of equal length.

The telson is no longer cleft, ending instead in a blunt point. It bears five pairs of minute lateral spines and seven pairs of setae.

IV. CHRONOLOGY OF LARVAL DEVELOPMENT

Experiments by the authors with larvae of the brown shrimp, *Penaeus aztecus* Ives, showed that growth is closely related to temperature, becoming more rapid the warmer the water. Consequently, it is likely that the growth of *S. brevirostris* would also be accelerated at temperatures higher than those encountered during this rearing trial (21.0° to 24.6° C).

In this study, the eggs were spawned at night and hatched the following afternoon. Each naupliar substage lasted approximately 12 hours. The number of days after spawning when the indicated substages were first noted are listed in Table I.

TABLE 1
Chronology of larval development

Substage	Days after spawning
Protozoaea I	3
Protozoaea II	6
Protozoaea III	10
Mysis I	12
Mysis II	16
Mysis III	22
Mysis IV	24
Postlarva 1	29

V. COMPARISON WITH DEVELOPMENT OF OTHER *Sicyonia*

As has been described, the larvae of *S. brevirostris* pass through five naupliar, three protozoecal, and four mysis substages before molting to the first postlarval stage. This sequence differs from that of the larval development of other (littoral) penaeidae in the northern Gulf area, most of which pass through only three mysis substages (Cook, in press), as well as from that of larvae of other *Sicyonia* spp. described in the literature (Table 2). One reason for the variation among descriptions by different authors may be that the number of substages is influenced by the environment in which the larvae grow. For example, Pike and Williamson (1964)

TABLE 2
Major differences between corresponding substages of four species of *Sicyonia* larvae¹

Stage and structure	<i>S. brevirostris</i>	<i>S. stimpsoni</i>	<i>S. wheeleri</i>	<i>S. carinata</i>
<i>Nauplius I</i>				Heldt attributes 8 naupliar substages to <i>S. carinata</i> . As illustrations of all substages are not given and setation is not described in detail, we have not attempted to compare this species with the other three. Length of the first nauplius is 0.26 mm and that of the last is 0.38 to 0.40 mm.
Length (mm)	0.30 (0.28-0.32)	0.24-0.26	See footnote 2	
Antenna II				
Endopod	2 lateral and 2 terminal setae	No lateral and 2 terminal setae		
Exopod	5 setae	4 setae		
Caudal spines	1 pair	1 pair		
<i>Nauplius II</i>				
Length (mm)	0.31 (0.29-0.34)	0.26-0.30	0.28	
Antenna II				
Endopod	2 lateral and 2 terminal setae	No lateral and 3 terminal setae	No lateral and 2 terminal setae	
Exopod	6 setae	5 setae	6 setae	
Caudal spines	1 pair	1 or 2 pairs	1 pair	
<i>Nauplius III</i>				
Length (mm)	0.35 (0.32-0.37)	0.30-0.36	0.34-0.37	
Antenna II				
Endopod	2 lateral and 3 terminal setae	No lateral and 4 terminal setae	No lateral and 3 terminal setae	
Exopod	7 setae	6 setae	7 setae	
Caudal spines	3 pairs	2 or 3 pairs	3 pairs	
<i>Nauplius IV</i>				
Length (mm)	0.37 (0.33-0.40)	0.36-0.40	See footnote 2	
Antenna II				
Endopod	2 lateral and 3 terminal setae	No lateral and 4 terminal setae		
Exopod	8 setae	7 setae		
Caudal spines	5 pairs	6 or 7 pairs		
<i>Nauplius V</i>				
Length (mm)	0.44 (0.38-0.46)	0.36-0.42	0.4	
Antenna I	2 long terminal setae	2 long terminal setae	3 long terminal setae	
Antenna II				
Endopod	5 lateral and 4 terminal setae	1 lateral and 3 terminal setae	4 lateral and 4 terminal setae	
Exopod	9 setae	8 setae	8 setae	
Caudal spines	7 pairs	7 pairs	6 pairs	
<i>Protozoa I</i>				
Length (mm)	0.81 (0.70-0.99)	0.70-0.80	0.7-0.75	0.76-0.86
Antenna I	5 terminal and 1 dorso-lateral setae	4 terminal and no dorso-lateral setae	5 terminal and 1 dorso-lateral setae	5 terminal and 1 dorso-lateral setae
Antenna II				
Endopod	1 + 2 + 3 lateral setae ³	2 + 2 lateral setae	1 + 2 lateral setae	1 + 1 + 2 lateral setae

<i>Protozoaea II</i>				
Length (mm)	1.23 (1.12-1.44)	1.0	1.02	1.23-1.30
Antenna I	5 terminal and 2 dorso-lateral setae	5 terminal and no dorso-lateral setae	5 terminal and 1 dorso-lateral setae	5 terminal and 1 dorso-lateral setae
Antenna II				
Endopod	1 + 2 + 3 lateral setae	2 + 2 lateral setae	1 + 2 lateral setae	1 + 2 + 2 lateral setae
<i>Protozoaea III</i>				
Length (mm)	1.96 (1.84-2.09)	1.36-1.68	1.32-1.5	[not given]
Antenna II				
Endopod	1 + 2 + 3 lateral setae	2 + 2 lateral setae	1 + 2 lateral setae	1 + 2 + 2 lateral setae
Abdomen	First 5 segments with spine on dorsoposterior border, 1 pair of posterolateral spines present on both the fifth and sixth segments	Dorsoposterior spine present only on third, fourth, and fifth segments; no posterolateral spines on fifth or sixth segments	First 5 segments with spine on dorsoposterior border; 1 pair of posterolateral spines on fifth segment and 2 pairs on the sixth	First 5 segments with spine on dorsoposterior border; 1 pair of posterolateral spines on fifth segment and none on the sixth
<i>Mysis I</i>				
Length (mm)	2.47 (2.16-2.66)	See footnote 4	1.66	2.05-2.39
Abdomen	Ventral margins of pleura of first 5 segments rounded; a pair of posterolateral spines on sixth segment		Ventral margins of pleura of first 4 segments pointed	Ventral margins of pleura of first 5 segments rounded; no posterolateral spines on sixth segment
<i>Mysis II</i>				
Length (mm)	2.89 (2.70-3.15)	2.0-2.8	1.8	2.6-2.8
Abdomen	Same as in Mysis I	Ventral margins of pleura of first 5 segments pointed	Ventral margins of pleura of first 3 segments pointed	Same as in Mysis I
<i>Mysis III</i>				
Length (mm)	3.51 (2.94-3.72)	2.8-3.6	2.37	2.95-3.04
Abdomen	Same as in Mysis I	Ventral margins of pleura of first 5 abdominal segments pointed; point arises from the middle of the segment on all segments	Ventral margins of pleura of first 5 segments pointed; point arises from the posterior portions on segments 3-5	Same as in Mysis I
<i>Mysis IV</i>				
Length (mm)	3.68 (3.48-3.81)	None recorded	None recorded	3.26
Abdomen	Same as in Mysis I			Same as in Mysis I

¹ Data on *S. stimpsoni* from Pearson (1939), on *S. wheeleri* from Gurney (1943), and on *S. carinata* from Heldt (1938).

² Gurney (1943) lists only three naupliar substages but concedes that he may have missed some. We have arbitrarily placed his nauplii into the second, third, and fifth substages as they appear similar to corresponding substages of both *S. brevirostris* and *S. stimpsoni*.

³ The number of setae at each point of insertion is recorded starting proximally.

⁴ Pearson (1939) recorded only two mysis substages, which we believe correspond to Mysids II and III of the other species.

found that under certain conditions, larvae of *Pandalus montagui* Leach reared in the laboratory passed through several additional zoeal substages before molting to megalopa. To ensure that the number of substages listed for *S. brevirostris* in this paper is the same as occurs in nature, and was not affected by the rearing procedure, a comparison was made with *Sicyonia* larvae in plankton samples. The number of substages found in a large volume of planktonic material was the same as that found among laboratory-reared larvae.

Larvae of three other species of *Sicyonia* have been described: *S. carinata* by Heldt (1938); *S. stimpsoni* by Pearson (1939); and *S. wheeleri* by Gurney (1943). Upon comparing descriptions of these larvae with specimens of *S. brevirostris*, we determined that in the protozoeal and mysis stages they possess morphological characters which permit their differentiation both from other penaeid larvae and from each other. Variation between nauplii of different *Sicyonia* often appears to be as great as that observed between penaeid genera at the naupliar stage, and there seemingly are no definitive characters by which they can be collectively separated from nauplii of other genera. This is due to the fact that penaeid nauplii are very simple forms having the same general shape and relatively few setae, all of which minimizes the possibility of distinctive, interspecific variation.

The following characters serve to distinguish *Sicyonia* protozoae from those of other penaeid genera: The first antenna is relatively long, about $1\frac{1}{2}$ times as long as the endopod of the second antenna, and bears three long terminal setae. The rostrum, when present, is very short with no supraorbital spines. The labrum does not possess a ventral spine, and the outer pair of caudal spines extends inwardly across the furcae.

The lack of dorsomedial spines on the first five abdominal segments is usually a sufficient criterion for identifying *Sicyonia* mysids. Other useful characters are the presence of ventromedial spines on the first five abdominal segments, and the absence of hepatic spines on the carapace.

As pointed out by Heldt (1938), metamorphosis among the Penaeidae is very gradual with relatively minor differences separating most substages. Because distinction

of successive substages can only be accomplished somewhat arbitrarily, different investigators examining the same kind of developmental material might easily have different opinions as to the number of substages represented. We believe this subjectively largely explains the variation in substage count recorded for *Sicyonia* larvae (Table 2). So, to facilitate comparison of the species described in Table 2, we have taken the liberty of placing the larvae of some authors in slightly different substage categories.

VI. SUMMARY

Five naupliar, three protozoeal, four mysis, and the first postlarval stages of the rock shrimp, *Sicyonia brevirostris* Stimpson, reared from eggs spawned in the laboratory, are described and illustrated. Temperatures during rearing varied between 21.0° and 24.6° C. Salinity, which was 24.5‰ at the start, rose to a maximum of 27.4‰. The pH varied from 8.06 to 8.20. Under these conditions, the larvae developed to the first postlarval stage in 29 days.

S. brevirostris larvae are compared with corresponding substages of three previously described species of *Sicyonia*. It was noted that the larvae of all four species possess characteristics which serve to distinguish them from one another.

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